Preliminary PM 2.5
BAM/TEOM/FRM Data

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MARAMA Monitoring Meeting
Richmond, VA
November 17-19, 2008
Brief History of the BAM

- 1930’s for paper thickness
- 1970’s pollution measures
- 1990’s PM 10 FEM
- 2002 E-BAM developed
- 2008 PM 2.5 FEM
Beta Attenuation

Carbon 14 beta rays are emitted to a detector. Particles absorb the radiation and the monitor measures the reduction in the Beta count in relation to the Beer-Lambert law.
BAM 1020

(Beta Attenuation Monitor)
Met One Instruments
Grants Pass, Oregon
August, 2008
FEM Status

EPA Granted Federal Equivalent Method (FEM) Status to the BAM 1020 for the Measurement of PM$_{2.5}$ on 3/12/08
To Maintain FEM Status the BAM 1020 Must:

- Provide 1-hour Average Concentration Values
- Provide at Least 18 1-hour Average Values per 24-Hour Period
- Provide Concentrations Based on Actual Flow (local ambient conditions of Temp./Pressure)
To Maintain FEM Status, Cont’d

- Use Firmware Version 3.2.4 or Later
- Use Tape Drive Transport 8470-1 Rev D or later
- Control Shelter Temperature to within ± 2 Degrees C over any 1-Hour Sampling Period
- Use a PM$_{10}$ Head and a PM$_{2.5}$ VSCC
To Maintain FEM Status, Cont’d

- Maintain Sample RH < 35%
- Use a Glass Fiber Filter Tape
- Sample for 42 Minutes of Each Hour
- Count Beta Particles For 8 minutes
- Operate at a Flow Rate of 16.67 LPM
BAM Operational Features

- Attenuation of Beta Particles
- Carbon 14 (exempt source)
- New Filter “Spot” Every Hour
- Hourly “Zero” and “Span” Checks
- Filter Tape Good for Two Months
- Changing PM Composition Has No Affect On Beta Attenuation
- Post Filter Analysis Possible
- Standard Range is 0 – 1000 ug/m³
Bam Operational Features, Cont’d

- Accuracy (24 hour Average) = ±2 ug
- Resolution = ±1 ug/m³
- Maintains Sample Stream RH < 35%
- Compatible With ESC Data Loggers
BX-802 
PM10 Head

BX-808 
BGI VSCC™
PM2.5 
Cyclone 
(optional)
BX-596 
AT/BP 
Sensor 
(or BX-592) 
Inlet Tube 
8119 Seal

BX-827 or 
830 
Smart 
Heater with 
Mounting 
Rack

BX-902/903 
Environmental Enclosure

BX-126 
Vacuum Pump 
or equivalent

adds 14.0”
adds 19.0”
27” typical 
Inlet tube

-Total Height-
6.6 ft (2.0 
meters) 
without cyclone
7.0 ft (2.1 
meters) 
with cyclone
BAM Components

1---NOZZLE IN "UP" POSITION
2---CLEAR SPOOL COVER WITH KNOB
3---EMPTY CORE TUBE
4---TAKE-UP SPOOL
5---PINCH ROLLERS
6---CAPSTAN SHAFT
7---LATCH
8---FILTER TAPE
9---SUPPLY SPOOL
10---SUPPLY TENSION ROLLER
11---RIGHT END ROLLER
12---SAMPLING/MEASURING AREA
13---LEFT END ROLLER
14---TAKE-UP TENSION ROLLER
Method Comparison
(Flow Rate Through Filter)

- FRM 16.7 LPM
- BAM 16.7 LPM
- TEOM 3.0 LPM
Method Comparison, Cont’d
(PM Collection Time Period)

- FRM      24 hours
- TEOM     Continuous 1 hr. Readings
- BAM      Continuous 1 Hour
Method Comparison, Cont’d
(Filter Material)

- FRM: Teflon
- TEOM: Teflon Coated Glass Fiber
- BAM: Glass Fiber
Method Comparison, Cont’d
(Filter Conditions)

- FRM: Subject to Ambient Conditions of Ambient Temp. and RH
- TEOM: Operates at 50 Degrees C
- BAM: RH Controlled to 35% or Less
Method Comparison, Cont’d
(Data Availability)

- FRM: 4-5 Days After Sampling
- TEOM: Hourly
- BAM: Hourly
TEOM vs BAM vs FRM (February)

Millbrook February

- **TEOM**
- **BAM**
- **FRM**

Graph showing the comparison of TEOM, BAM, and FRM over the course of February.
TEOM vs BAM vs FRM (March)

Millbrook March

Date

0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0

ug/m³


TEOM  BAM  FRM
TEOM vs BAM vs FRM
(April)

Millbrook April

Date

0.00
5.00
10.00
15.00
20.00
25.00
30.00

ug/m3

TEOM
BAM
FRM
TEOM vs BAM vs FRM (May)

Millbrook May

Date

ug/m³

TEOM
BAM
FRM
TEOM vs BAM vs FRM (June)
**Data Comparison**  
*(Avg. Monthly Concentration, ug/m³)*

<table>
<thead>
<tr>
<th></th>
<th>Feb</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June*</th>
<th>June**</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRM</td>
<td>11.1</td>
<td>10.2</td>
<td>8.5</td>
<td>11.5</td>
<td>19.9</td>
<td>17.1</td>
</tr>
<tr>
<td>TEOM</td>
<td>12.7</td>
<td>12.1</td>
<td>10.8</td>
<td>13.0</td>
<td>22.6</td>
<td>19.9</td>
</tr>
<tr>
<td>BAM</td>
<td>13.9</td>
<td>12.7</td>
<td>9.8</td>
<td>13.3</td>
<td>26.4</td>
<td>23.0</td>
</tr>
</tbody>
</table>

* Includes 6/12/08 Exceptional Event  
** Excludes 6/12/08 Exceptional Event
Data Comparison, Cont’d
(Avg. Monthly Conc. Difference vs FRM, ug/m³)

<table>
<thead>
<tr>
<th></th>
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<th>June*</th>
<th>June**</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEOM</td>
<td>1.6</td>
<td>1.9</td>
<td>2.3</td>
<td>1.5</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td>BAM</td>
<td>2.8</td>
<td>2.5</td>
<td>1.3</td>
<td>1.8</td>
<td>6.5</td>
<td>5.9</td>
</tr>
</tbody>
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* Includes 6/12/08 Exceptional Event
** Excludes 6/12/08 Exceptional Event
### Data Comparison, Cont’d
(BAM vs TEOM)

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<th>May</th>
<th>June*</th>
<th>June**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. ug/m³ Diff.</td>
<td>1.2</td>
<td>0.5</td>
<td>-1.0</td>
<td>0.7</td>
<td>3.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Avg. % Diff.</td>
<td>8.9</td>
<td>6.4</td>
<td>-11.4</td>
<td>4.5</td>
<td>16.1</td>
<td>15.8</td>
</tr>
</tbody>
</table>

* Includes 6/12/08 Exceptional Event

** Excludes 6/12/08 Exceptional Event
### Data Comparison, Cont’d
( Exceptional Event of June 12, 2008, FRM vs TEOM vs BAM )

<table>
<thead>
<tr>
<th></th>
<th>FRM</th>
<th>TEOM</th>
<th>BAM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-Hr. Avg., ug/m³</td>
<td>99.0</td>
<td>102</td>
<td>127</td>
</tr>
</tbody>
</table>

* BAM Measures Volatile Components Lost by FRM and TEOM
BAM-TEOM-FRM Multiple Comparisons at Millbrook, Feb-Jun 2008

All Samples

Omitting 06/12/2008 Sample

Factors

mean of pm24h

monitor months(hdate)

BAM
TEOM
FRM

Jun
May
Mar
Apr
Conclusions
(Based on Limited Data)

- BAM & TEOM* > FRM by up to 20-25%
- BAM > TEOM by up to 5-6%
- Including 6/12/08 Exceptional Event Data
  - BAM & FRM are Significantly Different
  - BAM & TEOM are not Significantly Different
  - FRM & TEOM are not Significantly Different

Loss of Volatile PM Reason for Difference

- Need 1 Year of Data From the 3 Proposed Sites
- * TEOM is normally corrected to be FRM-like
Questions ?